General Application Name: Planning

Product / Service / Function Name: Wireless Communication (Existing & Proposed Tower Site Analysis)

P/S/F Description:

Wireless communication is one of the most rapidly growing industries worldwide. Whether it is cellular phones, pagers, wireless Internet connections, or more traditional systems such as radio and television broadcasting, wireless communication has become a vital component of fundamental societal infrastructures that rivals in importance traditional transportation, electric and water systems.

As these wireless networks are extended and expanded, the need to place new communication towers is needed. The placement of these towers is dependent upon many factors, including demographics, terrain, and zoning district ordinances. The combination of these geographic factors suits GIS as an ideal tool to plan for existing and proposed tower site analysis.

Product / Service / Function

1. Spatial Data

Minimum Requirements

General Description	Data Layer
Wireless Communications	Tower Site Locations
Land Base / Planimetric Data	Street Centerlines
	Rivers and Streams
	Municipal Boundaries
	County Boundaries
	State Boundaries
	Zoning Districts
	Lakes and Ponds
	Digital Elevation Model (DEM)
Socio-Political Data	Census Tracts
	Census Block Groups
Business Data	Basic Trading Areas (BTA)
	Major Trading Areas (MTA)

Optional Requirements

General Description	Data Layer
Land Base / Planimetric Data	Building Footprints
	Street Right-of-way
	Land Use
	Tax Parcels

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	Contours
	Triangular Irregular Network (TIN)
	Digital Orthophotography
Transportation Data	Transportation Area Zones (TAZ)
Business Data	Metropolitan Statistical Areas (MSA)
	Component Economic Areas (CEA)
	Cellular Market Areas (CMA)
	Regional PCS Areas
	Basic Economic Areas (BEA)
	Major Economic Areas (MEA)
	Regional Economic Areas (REA)
	Economic Area Groupings (EAG)

2. Attribute Data –

Minimum Requirements

General Description	Field Name
Wireless Communications	FCC Tower Name
	Tower Height
	Tower Type
	Antenna Height
	Antenna Type
	dB Gain
	Frequency
Zoning	Zoning Code
Census Data	Population
	Income
Business Data	Trading area identifiers

Optional Requirements

General Description	Field Name
Buildings	Building Height
Land Use Data	Land Use Code
Tax Data	Owner Name
	Property Address
	Owner Address
	Tax Parcel ID Number
	Map Number
	Acreage
	Assessed Value
	Market Value
Transportation Data	Zone Identifiers

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3. Data Acquisition Options (integrated with VBMP digital orthos)

   There are many publicly available sources to acquire spatial data. Current FCC licensed tower site locations, census information, and business data, as well as an assortment of other data and applications are freely available via download from the Federal Communications Commission at <http://www.fcc.gov/oet/info/maps/Welcome.html >. Most likely, proposed tower site locations will need to be located via traditional survey, GPS, or by identifying a location on an orthophoto. This data will need to be converted to a GIS format and projected to appropriate coordinate system.

   Land base and planimetric data are typically generated at the county level. County staff may create this data themselves or contract the project out to a consulting firm. This data often includes tax parcels, zoning districts, land use, parks, open water, and street right-of-way information.

   The leading source of commercial wireless infrastructure data is MapInfo Corporation (www.mapinfo.com). They maintain a large assortment of quickly changing data, such as cellular service areas, which can be purchased on a subscription basis. Other vendors of street centerline and demographic information include Navigation Technologies (NAVTECH) (www.navtech.com), Geographic Data Technologies (GDT) (www.geographic.com), and TeleAtlas (www.teleatlas.com).

   Regardless of the source of the data, each data layer used for tower site analysis should be consistent with, or be modified to match, the Virginia Base Mapping Project orthophotography. The digital orthophotography provides an excellent base data layer on which to choose preliminary site locations and to symbolize tower sites and coverage areas.

4. Data Conflation Options (integrated with VBMP digital orthos)

   Data conflation is a process by which two digital data layers, usually of the same area at different points in time, or two different data layers of the same area, are geographically "corrected" through geometrical and rotational transformations so that the different layers can be overlaid on one another. Also called "rubber-sheeting," this process allows a technician to adjust the coordinates of all features on a data layer to provide a more accurate match between known locations and a few data points within the base data set. A good base layer to use for data conflation is the VBMP orthophotos since many features can be seen or interpreted. The need and processes for conflation varies between sets of data, users, and feature types. Any dataset that is updated independently by different departments can be consolidated through conflation. Within most local governments, individual departments are responsible for maintaining specific datasets within their expertise; therefore, conflation is not often necessary. Often, reprojecting the data into a different coordinate system will take care of the misalignment of different data sets. Most industry-standard GIS software has the ability to perform data conflation.

   Each data layer used for tower site analysis should use the Virginia Base Mapping Project orthophotography for data conflation. For instance, if a GIS tower layer is projected to a different datum or coordinate system than the underlying DEM, the analysis for coverage area will be incorrect, because it is based on line of sight (a function of elevation).

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5. GUI / programming options

There a few options for developers of desktop tower site analysis application. Two avenues within this development track are:

- Using standard GIS desktop software that can be customized to the user's needs
- Hiring a consultant to develop a custom system from scratch

Using a standard GIS software package often requires a significant amount of training and customization. Whereas the initial cost may be low, the time invested in learning these solutions may generally increase the overall expense of implementation. GIS based software packages deliver more robust data integration, analysis, and cartographic capabilities than do engineering based tower site analysis applications. They have a greater user support infrastructure that allows users to overcome problems quickly. Options for using an existing, industry-standard GIS software application that can be customized for tower site analysis include those listed in the following table:

Standard GIS Software Vendors:

Vendor	Software	Add-ons	Web Address
ESRI	ArcGIS 8.x	Network Engineer	www.esri.com
MapInfo	Professional v7.0	Decibel Planner	www.mapinfo.com
Intergraph	GeoMedia 5.0		www.intergraph.com/gis
Manifold	Manifold 5.0		www.manifold.net

Another option for developing and implementing a GIS-based tower site analysis application is to contract with a consultant. This option makes certain that a product will fulfill, with a great deal of precision, a jurisdiction's requirements. A consultant will be able to develop an application that works with the wide range of hardware and software that are currently in use within local governments within Virginia. Also, training and follow-up user support is often provided at a much more substantial level than with other options.

A tower site analysis application can offer planners a wide range of capabilities. To aid planners in locating a new site for a tower, the GIS application could be customized to accept certain parameters (such as terrain height, environmental impact, and availability of property) to determine potential locations for a new tower. An automated site selection tool would dramatically reduce the amount of time it would take to locate potential properties. For towers that already exist, a GIS application can generate the transmission zone or corridor for the tower. This would allow planners to determine which areas of their jurisdiction are not currently covered for wireless service. Another potential time and money saving function is to have the ability to access building permit information from within the GIS. Planners would be able to determine whether or not a proposed building will interrupt wireless communication due to its height. The building permit would be accepted or rejected accordingly, before any construction has taken place.

6. Internet Functionality and options

Tower site analysis is a very intensive processing application and is usually not suitable to be deployed as an Internet, or even an intranet application. However, the results of such analysis, as

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well as base data could be easily deployed using a common GIS mapping package. Information such as wireless coverage maps or tower locations could be deployed on the Internet. The following are software available for publishing map-based data on the Internet or an intranet.

GIS Internet Solutions

Vendor	Internet Software	Web Address
ESRI	ArcIMS	http://www.esri.com/software/arcims
MapInfo	MapXtreme, MapX	http://www.mapinfo.com
Intergraph	GeoMedia WebMap	http://www.intergraph.com/gis/gmwm
Autodesk	MapGuide	http://www.autodesk.com

7. Technical Requirements

Minimum Technical Requirements

At its most basic level, tower site analysis application can be used on a single, stand-alone workstation. This workstation would have a hard drive that stores all of the spatial data layers and other associated tabular data. A typical workstation running off-the-shelf software should have the following minimum specifications:

Processor:	Pentium 3, 450 MHz
RAM:	128MB SDRAM at 133MHz
Hard Disk:	20GB (min.)
Monitor 1:	19"
Floppy Drive:	3.5”
CD-ROM:	12x/8x/32x CD drive
Modem:	56K
OS:	Windows 2000/NT/XP
Office:	Windows 2000 Professional
Printer:	8x11 office-grade color printer

Optimum Technical Requirements

A more intensive tower site analysis application may require multiple components, including servers and desktop workstations. Example specifications of the necessary equipment are listed below:

Server

Processor:	Min. 2x Processors, 1.7 GHz, 512K cache
RAM:	Min. 2x 512MB RIMMS
Hard Disk:	Min. 2x 80GB +RAID
Monitor 1:	19"
Floppy Drive:	3.5”
CD-ROM:	12x/8x/32x CD drive
Modem:	56K
Network Card:	10/100 mbps

Workstation

Processor:	Pentium 4, 1.5 GHz
RAM:	512MB SDRAM at 133MHz
Hard Disk:	20GB (min.)
Monitor 1:	19”
Monitor 2:	17”
Floppy Drive:	3.5”
CD-ROM:	12x/8x/32x CD-RW drive
Modem:	56K
Network Card:	10/100 mbps
OS:	Windows 2000/NT/XP
Office:	Windows 2000 Professional

Other Components

Printer:	8x11 office-grade color printer and 8x11 production b/w printer
Plotter:	HP DesignJet 1055CM
Tape Backup:	Tape Library Server
UPS:	APC 1400 (or other similar)
Scanner:	11x17
Handheld:	Compaq IPAQ
Network:	T1

8. Administrative/Management Requirements

At the beginning of the project, the assigned committee member from the particular municipality should consider completing some, if not all of the following tasks that relate to the administrative requirements of a tower site analysis system:

- Determine, with or without the assistance of a consultant hired to develop the system, the preliminary vision and goals of the project.
- Coordinate an initial meeting with the decision-makers (e.g. Board of Supervisors, City Council, public works department, engineering department, wireless communication companies, emergency response agencies, etc.) where the vision and goals of the project are expressed and the background of GIS technology is described, if needed.
- Coordinate with other municipal agencies for data sharing provisions.
- Determine a mechanism of communication to keep the decision-makers aware of the progress of the project.
- Develop a basic understanding of the available precedents in the region/state and research the available technologies that can be applied to the project.

Upon project completion, a basic GIS-based tower site analysis application will require very little administrative support. Administrative tasks may include loading or upgrading new versions of the software or patches, providing for constant data flow from the source database, and maintaining yearly support contracts on the hardware and software. However, once the system becomes distributed as an enterprise solution to many users throughout a department or deployed on the Internet, there are various other management requirements that need to be fulfilled on a weekly or monthly basis.

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At the point where the system grows beyond single desktop users, a devoted administrator or system manager needs to be established. This is essential for the following reasons:

- The system will now be interfacing with other technology systems already in place. Therefore, someone needs to maintain contact with the technology personnel that maintain these systems.
- The manager needs to put into place training schedules to maintain user knowledge of the system.
- Funding will undoubtedly be required to either maintain the system long-term, or continue to expand the system, which requires funding research and applications for grants.

9. Cost – Cost/Benefit

Hardware	**Typical Unit Cost**
Minimum Workstation	$2,000
Optimum Workstation	$3,200
Web/FTP Server	$8,500
Database Server	$12,000
Backup Server	$5,800
Printer (8x11 color)	$700
Printer (8x11 b/w production)	$2,000
Plotter	$12,000
Tape Library	$5,000
UPS	$700
Scanner	$1,500
Handheld	$300-$700

Software (all prices included license)	**Typical Unit Cost**
Standard GIS desktop software	$700-$10,000
Desktop vendor tower site analysis and mapping application	$2,000-$6,000
Customized desktop vendor solution	$5,000-$15,000

Miscellaneous	**Typical Unit Cost**
Training – focused tower site analysis training (per person)	$700-$1,000
Training – general GIS	$700-$1,200
Licensing-desktop	$100-$500
Maintenance (per year)	$8,000-$15,000

10. Standards / Guidelines Summary

- Always maintain a unique identification number with every spatial feature, and event recorded within the system.
- Standardize naming conventions for data sets, feature names, and codes.

- Standardize street naming conventions to make certain of proper geocoding, then standardize additional fields, such as borough name or zip code, that are collected to differentiate the streets.
- Create a standard model for tower site selection analysis by defining the parameters for potential locations. This model will serve as the logic behind the customization of the GIS application.
- Standardize data entry and editing procedures. Data entry procedures will need to be integrated with staff work routines to promote accurate and reliable spatial and attribute data when developing new data sets or updating existing datasets.
- Develop a detailed Quality Assurance/Quality Control (QA/QC) procedure for reviewing the accuracy of the GIS data and its attributes.
- Maintain data in the VBMP standard coordinate system (Virginia State Plane, NAD 83, Survey Feet).
- Create metadata (standard information about GIS data) for each data layer. Metadata tracks the date, origin, coordinate system, and other such information for data layers.

11. Startup Procedures/Steps

There should be a minimum of eight steps involved with developing a tower site analysis application, after funding is in place to support the project. The steps can be performed in-house or by a consulting team.

The first task is to complete a detailed Needs Assessment. This process gathers information regarding existing operational procedures, hardware and software, GIS data, and personnel needs. It should include interviews of key individuals throughout the local government agency and other related government departments or private firms to obtain a comprehensive view of the agency's operations, and where GIS might improve them. Basic GIS concepts should be discussed and illustrated to those interviewees that have little prior understanding of GIS. A comprehensive Needs Assessment should then be compiled from the results of the interviews. This document explains the various requirements for a tower site analysis application in the following areas: personnel needs, spatial data development needs, applicable spatial analysis techniques, basic system requirements, including preliminary, general hardware and software recommendations, and training needs.

The second task is to develop a functional requirements document for the proposed application. This document should describe, as completely as possible, all of the technology and functionality that is to be included in the system. This document is used by the local government agency, or its consultant, as the blueprint for the GIS application or system. The following topics should be included:

- Hardware specifications
- Software purchases
- Detailed descriptions of work-flow, and examples of the graphic user interfaces
- Describe each tool that is part of that graphic user interface, and its functionality
- Describe how data would flow between the different databases and data warehouses, if applicable
- Describe the redundant security measures that will be put in place to make certain of data integrity and confidentiality, when applicable
- Analytical techniques that the application/system provides the user for tower analysis functions

- Describe each of the potential products (reports, maps, charts, summary tables) that the user will be able to generate within the system

The third task should be to compile or develop spatial data that can be used by the application. Data can be gathered from a number of online sources, as well as county/city departments. The data layers gathered and maintained should match at least the minimum list provided in Section 1 of this document and can be acquired through the methods described in Section 3 of this document.

On completion and acceptance of the functional requirements document and the development of the spatial and attribute data, the system development and test phase can begin. During this time, the application will be customized as it was outlined in the functional requirements phase. The local government agency should require periodic reviews of the application at particular milestones, such as 50% and 75% completion. This will make certain that problems with the application will be recognized early in the development process, and that the local government agency remains a part of the development process throughout the project timeline.

When the application is nearing completion, it should be installed and tested in the environment in which it will ultimately be used. This allows the users to test the system alongside the application developers, and determine any system integration problems that might arise. It also gives the developers the opportunity to test the application's functionality in a real-world situation. This testing process should be as comprehensive as possible. Each process detailed within the functional requirements should be tested and evaluated at this point.

User training commences once the application reaches completion and is fully documented. Different levels of tutorials and system documentation should be developed depending on the hierarchy of users. Time should be spent at this stage of the project with each potential user of the system to make certain that the proper education occurs. Training should be done through lessons that use real-life examples of system application. This strategy greatly enhances users' ability to apply the functionality to their jobs.

The next phase of the project should include a document that describes a future plan for wider system development. This document accomplishes two goals. The future plan gives the local government agency ideas on how the system might grow to assist other facets of its business practices. Secondly, it provides the agency with a ready-made grant proposal for applying for potential funding sources.

The final phase of a successful implementation of a GIS-based tower site analysis application is ongoing technical support. The local government agency should always include this contingency within its cost estimates of a project for a minimum of three months after a system has been put into place. No matter how effective an application appears, problems and system changes inevitably impact the functionality of an application.

12. Estimated time line and/or implementation (stand alone) schedule

Phase	Duration
Needs Assessment	1 month
Data Development	2-3 months
User Training	½ month

Plan for Future Development	¼ month
Ongoing Support	3 months

13. Best Practice Examples in Virginia

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http://www.ci.richmond.va.us/department/gis/index.asp